IOWA STATE UNIVERSITY
Senior Honors Project
College of Engineering
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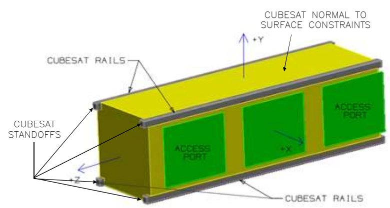
Structural Design Methodology and Analysis for Small-Sats/CubeSats

Objectives

1. Provide literature review of basic structural requirements from launch providers/CubeSat standard, and analysis and test procedures
2. Define components and requirements for structural subsystem as well as suggested sample loading for a generic launch provider
3. Perform a structural analysis and document the design process used for the Iowa State *CySat* team's custom CubeSat



Introduction

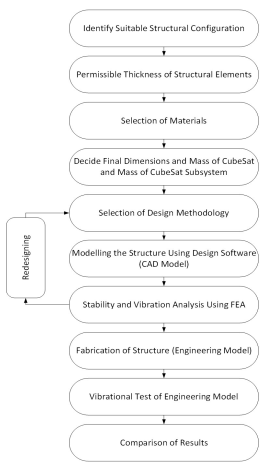
A CubeSat is a subset of satellite which follows much more restricted design parameters. They are often launched as secondary payloads on large satellite launches at little cost but achieve more narrow goals. These CubeSats are a favorite of universities as they provide cheap access to space and allow students to conduct valuable science missions.

A problem with CubeSats is that they require a lot of design work before ever gathering the data that the designers want in the first place. The only available options are to have a 3rd party build them or to spend years designing their CubeSat (CySat has been designing a CubeSat for 3 years). To reduce the design time, effort, and cost of creating these structures, this research strives to create a framework through which a customized design can be completed cheaply and efficiently.

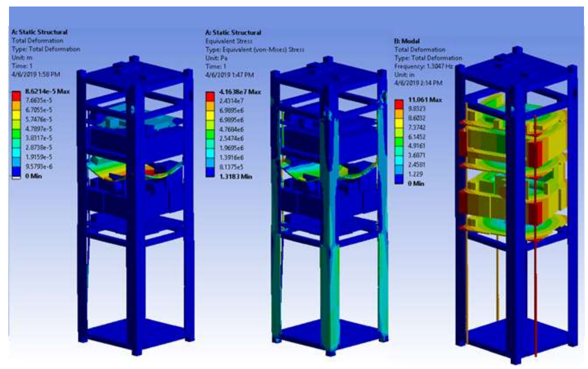
Methods

The knowledge and experience for this research was gathered over the three year development process of the CySat structure. The literature review was conducted in the initial stages of design and reconducted at the start of this research by analyzing previous CubeSat missions and learning from their design methods and choices. To verify these methods, a composite methodology was designed and used to create the CySat structure. The data used here is pulled directly from the CySat development cycle and meets all the requirements from both NASA and the deployer, Nanoracks.

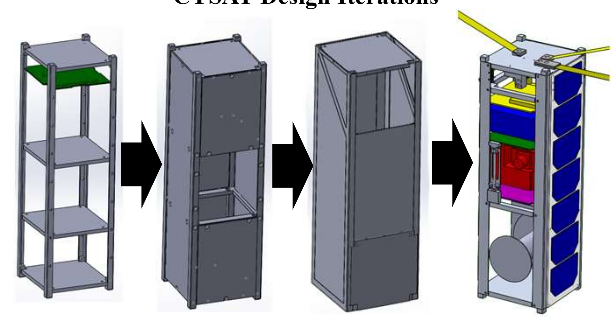
Structures Design Flowchart



Structures Components	Description/Restraints
Rails	The rails hold the CubeSat within the PPOD system and are the only components that touch the PPOD. They must be 8.5 mm wide with a surface roughness less than 1.6 µm. Must have rounded edges and be hard anodized aluminum.
Standoffs	The standoffs constrain the ±Z motion of the CubeSat in the PPOD and either connect to other CubeSats (for <3U) or to the PPOD. Must extend 6.5 mm normal to top surface and be rounded to 1 mm.
Access Ports	Access ports allow the removal of RBF pins and access to internal components when all external panels are mounted. A minimum area of open access port must meet the requirement ventable volume/area < 2000 in.
Normal Surfaces	These surfaces protect the internal components from the space environment and hold the solar panels. Deployable arrays and antennas may be included but all yellow and green surfaces must be self constrained to 6.5 mm
Rods (Not Pictured)	Holds the boards in place inside the satellite and must be spaced according to the standard Cubesat board specification
Switches (Not Pictured)	Either emerges from the rails or the standoffs and detects when the Cubesat emerges from the PPOD.



CYSAT Design Iterations



Results

Cubesats come in a variety of different sizes, shapes, and styles but each is held together by a unique structure that is tailored to that specific mission. While all CubeSat structures are similar, due to the myriad of design requirements on them from the Cal Poly Standard, Deployer ICD's, and NASA guidelines, their unique features require a structural engineer for design, analysis, and fabrication. After analyzing several CubeSats in this research, a generic flowchart that provides a strong design methodologyfor generic structure creation could be developed and suggested testing methods using ANSYS or other modelling software were created. These tests ensure that a CubeSat meets the requirements laid out in GSFC-STD-7000 and other test level documents. Using this design methodology as a basis, the CySat structure was developed and analyzed to prove the validity of this method and how future structures can be developed at Iowa State. A full report detailing the design process for CySat has also been created.

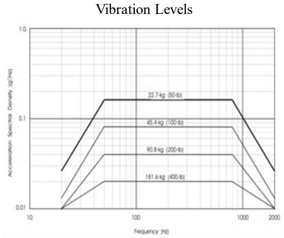
Conclusion

The design of a CubeSat is heavily influenced by the design of the structures subsystem. All other subsystems must integrate with the structure and if it is not properly designed, the mission can fail at any point in the development process. It is also the responsibility of the structures team to ensure other subsystems understand the physical constraints of the satellite and to use their engineering judgment to determine the best possible solutions.

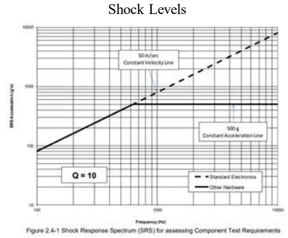
The most important thing to remember through the design process is that if anything doesn't make sense, work should be halted and a proper source should be contacted to clarify things. Any guesswork can set back the team by months, lead to wasted resources, and potentially the loss of the satellite. If this simple rule is followed and the design process described herein is understood, it is possible to create a custom CubeSat that can meet any mission parameters.

Structural Testing Levels - GSFC-STD-7000

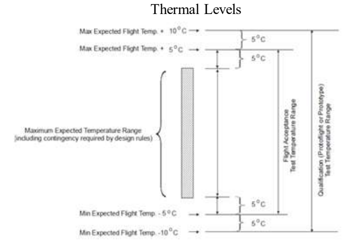
Vibration Levels



Shock Levels



Thermal Levels



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